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The Turn-around in the Production Pattern and International Geography by the Foreign Innovation

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Abstract

The main framework is based on the two good—two country—three region Ricardian Model, including migration. We manifest that, even if the technology is improved in the foreign country at a moderate level so as not to exceed the technology in one advanced region in the home country and so as to surpass that of the other less advanced region, the production pattern will totally change between the home country and the foreign country by people concentrating in the technologically less advanced region in some cases. On the other hand, through the concentration on the advanced region, the production pattern will not change at all despite of innovation, and the foreign country may reverse to the original production pattern before the innovation.

Keywords: Innovation, Production pattern, the Ricardian Model, Migration, Transportation costs, Concentration, Dispersion

JEL Classification Numbers F14 R13 R12

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1. Introduction

In the 1990 many Asian countries grew up at the extremely high rate. Many economists have paid much attention on it, and devoted their energies to the analyses. At the almost same moment, the transformation of internal geography has occurred in the U.S.. The center of much industry has transferred from the Northeastern industrial area to the West coast states, and the population in the West has gradually increased[1]. Also in the West states, the agricultural products speed up production and exportation to the Asia, while the manufacturing goods are produced increasingly. What causes the structural change and geographical change? What is the relationship between internal change in the U.S. and the rapid growth and industrialization in Asian countries?

This paper will analyze the following three main points. First, we consider the impacts of the industrialization and innovation in the foreign (developing) countries to the location and migration in the home (developed) country. We examine whether the effects of innovation in the foreign countries are beyond the national border or not. Next, we analyze the effect of innovation on the turn-around in the production and trade pattern, and explore the necessary degree of innovation for the change. Finally, the role of transportation costs is considered, which will analyze the effect of the reduction of tariff and the development of transportation network between regions[2].

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[1] MITI (1997) calculated and showed the change in the share of the employee and output in each region to the U.S., and concluded that the West and the South have grown up, while the Northeastern has declined. See Department of Commerce (1999) on the minute statistics about the transformation in the states in the U.S..

[2] Krugman and Livas (1996) mattered about the internal geographical change in Mexico,

The framework of this paper is two-good and three-region Ricardian Model. Three regions are made up of two regions in the home country and the rest of the region is in the foreign country. The similar three-region model is presumed in some former works, like Fujita, Krugman, and Venables (1999) and Krugman and Livas (1996), in the monopolistic competition model[3]. There are no former studies on the relationship between the technological innovation in the foreign country and the internal geography. But the topic on the only technological innovation is analyzed at the country level in Brezis, Krugman,and Tsiddon (1993), though the viewpoints of the geography are ignored[4]. The relationship between technology and transportation costs was considered by Takahashi (2000), which showed the trade-off between the technology in the foreign country and transportation costs in the home country by means of the two-good three-region Ricardian Model[5].

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accompanied by free trade with the U.S..

[3] Fujita, Krugman, and Venables(1999) examined the relationship between interregional trade and international trade, and suggested that the decrease of international trade costs leads to disperse to the two regions in the home country. Krugman and Livas (1996) also reached the same conclusions from the slightly different setting. These former studies used the monopolistic competition model, but this framework cannot envisage technological change and the change of production pattern and trade pattern.

[4] Brezis et al. (1993) indicated in the no-transportation costs framework that if a new manufacturing goods technology that is higher than the developed country is invented and introduced by the developing country, which specializes in agriculture in the initial equilibrium, these countries totally change the production pattern and trade pattern by the developing country exceeding the developed country in technology level. At last the developing country completely specializes in manufacturing, while the developed country falls down to the specialization in agriculture, though it is a natural result because the higher technology of manufacturing is available for the developing country. They called this perfect reverse of production pattern to be leapfrogging.

[5] Collins (1985) proposed three country-continuum good Ricardian model, and examined

This paper analyzes the impacts of the innovation in the foreign country (the Asian developing country) on the change of the internal geography and production pattern in the home country (a developed country like the U.S.) by means of the two—good and three—region Ricardian Model, like Takahashi (2000). We examine whether the foreign country can interchange the pattern of production just through not so large scale of innovation in the foreign country.

In this paper, 'the turn-around in production pattern', 'industrialization' and 'the failure of the innovation' are defined as follows. 'The turn-around in production pattern' is defined as the production pattern that the foreign country specializes in manufacture in the foreign country, while the home country falls down to the specialization in agriculture or produces agricultural goods as wall as manufacturing goods through the lower technology than in the foreign country. Then 'industrialization' is defined as the production pattern that the innovation makes the foreign country begin and continue to produce manufacturing goods, though the advanced region in the home country continues to produce them. Finally, 'the failure of the innovation' means that the foreign country reverses back to the specialization in agriculture despite the innovation.

In the final equilibrium, the turn-around in production pattern causes from concentrating on the West (the less advanced region), and the industrialization leads dispersion in the home country, and the failure of innovation comes from the people concentrating on the East (the advanced region).

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the influence on the welfare of the technological innovation. He concluded that the welfare in the country where innovation occurs increases, and that in the country that has similar technological structure and produces substitutional goods decreases.

The conclusions in this paper are four points. First, even if the foreign country has lower technology through innovation than that of the higher technology region in the home country, the foreign country and the home country can turn around the production patterns. This is contrast to Brezis et al. (1993). Second, the smaller scale of innovation in the foreign country can tend to lead 'the turn-around in the production pattern'. Also, the higher international transportation cost can encourage this trend. Third, the large innovation in the foreign country may lead to reverse back to agriculture, despite of innovation in manufacture. Finally, in the case of the starting from the concentration on the higher technological region, the foreign innovation may cause the home country not to reach the stable equilibrium, in which migration continues from the instability forever.

This paper has six sections. In the next section, the basic framework of the model is proposed, and in section 3, the changes of the production and trade pattern in the case of the starting from the concentration on the West. In section 4, we discuss another case: the starting from the concentration on the East. Section 5 supposes some implications, compared with some former studies. The final section leads conclusions.

2. Basic Model and Assumptions

The framework in this paper presupposes 2 countries and 3 regions, and the home country is made up of two regions which are called the West and the East, and the rest of the region is in the foreign country. Three regions lay on the line and the location

order is the Foreign country—the West—the East.[6] In this economy, 2 goods are composed of agricultural good (numeraire)(good A) and manufacturing good (good M). Transportation costs, which are presupposed to be of the iceberg type proposed by Samuelson (1954), are imposed on both goods at the rate of the reverse of τ ($0<\tau<1$) between the West and the East. Similarly the rate of the reverse of σ is imposed on the goods conveying between West and Foreign country. So the transportation cost ($1/(\tau \sigma)$) is imposed between the East and foreign country[7]. All consumers in each region have the identical Cobb-Douglas utility function, where μ is assumed to be the ratio of the expenditure to manufacturing good in individual income, and is assumed to be more than 0.5[8].

The factor to produce is the only factor (labor). In the home country, all of the habitants can move between two regions, the East and the West, deciding whether to migrate or not on the basis of the relative utility per capita in the two regions. The population is assumed to be distributed two countries equally like Brezis et.al (1993) (the home country and the foreign country are assumed to be equally L).

The production function for good A is defined as X=L, which is numeraire. That of good M is shown as Y=L/a, which is assumed the input coefficient **a**. In the initial equilibrium, the West already has adopted the lower technology in good M, and the East has done the highest technology, where input coefficients are assumed to be $a^W > a^E$ and given constant values. Also the potential technology ($\bar{a}^F$) in the foreign

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[6] We might presume the situation that the foreign country is correspondent to Japan or one of the Asian countries and the home country is the U.S..

[7] If 1 unit is dispatched from a firm, only τ units of the good remains and $1-\tau$ units melt away until it is arrived at the destination.

[8] Brezis et al. (1993) set the same assumption for the simplicity of the analysis.

country is much lower level than in the East and in the West before the innovation, ($\overline{a}^F > a^W > a^E$)[9].

3. The case of Concentration on the West

First of all, we argue about the case of the concentration on the West in the initial equilibrium, which requires the necessary condition that the utility in the West is absolutely higher than that of the East in the initial equilibrium.

The hypothesis is that the West completely specializes in good M, whereas the foreign country completely specializes in good A[10]. Figure 1 shows the offer curves.

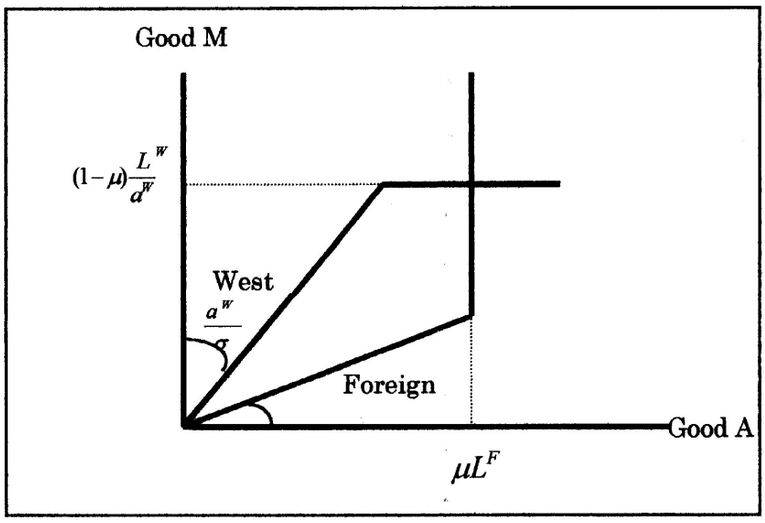

Figure 1 The offer curves in the foreign country in the initial equilibrium

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[9] This is presumed location specific type of technology. For example, pulp, paper product, beverage, mining and semiconductor industries much more depend on the circumstances of natural resources such as clean water and air or much minerals. Of course, agriculture is dependent on the fertile land, a mild climate, and topography.

[10] See the initial production pattern conditions in Appendix 1.

Prices of each good in the West are written as

$$p_M^W = a^W w^W, \quad p_A^W = \frac{w^F}{\sigma}, \tag{1}$$

which imply that transportation cost causes good A price to be higher, for being imported from the foreign country. From (1), the term of trade is given as

$$\left(\frac{p_M}{p_A}\right)^W = \frac{a^W w^W \sigma}{w^F}. \tag{2}$$

Similarly, terms of trade in the foreign country and the wage rate ratio of the West and foreign country are

$$\left(\frac{p_M}{p_A}\right)^F = \frac{a^W w^W}{w^F \sigma}, \tag{3}$$

$$\frac{w^W}{w^F} = \frac{\mu}{1-\mu}\frac{L^F}{L^W}. \tag{4}$$

Next, the initial concentration condition is induced, which is necessary for the initial equilibrium of the concentration on the West. The terms of trade in the East are

$$\left(\frac{p_M}{p_A}\right)^{Ep} = \frac{a^E w^E \sigma\tau}{w^F}. \tag{5}$$

Then we consider the utilities in the West and the East, when a few people deviate from the West to the East, shown as:

$$V^{Ep} = \frac{w^E}{e(P_1^E, P_2^E)} = \frac{1}{\left[\left(\frac{\mu}{1-\mu}\right)^{1-\mu} + \left(\frac{1-\mu}{\mu}\right)^{\mu}\right](a^E)^{\mu}\left(\frac{1}{\sigma\tau}\right)^{1-\mu}}\left(\frac{w^E}{w^F}\right)^{1-\mu}, \quad (6)$$

$$V^{w} = \frac{w^w}{e(P_1^w, P_2^w)} = \frac{\frac{a^E}{a^W\tau}}{\left[\left(\frac{\mu}{1-\mu}\right)^{1-\mu} + \left(\frac{1-\mu}{\mu}\right)^{\mu}\right]\left(\frac{a^E}{\tau}\right)^{\mu}\left(\frac{1}{\sigma}\right)^{1-\mu}}\left(\frac{w^E}{w^F}\right)^{1-\mu} \quad .(7)$$

(e indicates the individual expenditure function for unit utility)

From these two utility equations, since the necessary condition for concentration on the West is that the utility in each region, the relative utility function has to be less than unity,

$$V = \frac{V^E}{V^W} = \frac{a^W}{a^E}\tau^{2(1-\mu)} < 1 \quad [11]. \qquad (8)$$

This condition draws the situation of higher interregional transportation costs in the home country (smaller τ) and smaller gap of technology between the two regions.

Innovation in the foreign country and the change of production pattern

A newly invented technology and some improvements of the infrastructure or the

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[11] We call this the initial concentration (IC) condition, which is also induced in Takahashi (2000).

farm land made in the foreign country at some time will assume to cause the technology in the foreign country to surpass that of the West but not to overcome that of the potentially existing East[12]. Only the foreign country can enjoy such a moderate level of the innovation in the foreign country[13]. The level of technology is shown as $\bar{a}^F > a^W > a^F > a^E$, and a^F indicates the input coefficient after the innovation.

After the innovation the production pattern changes. Two cases are supposed. Case 1 is that the West incompletely specializes in both goods while the foreign country completely specializes in good M, shown as figure 2. Then case 2 is that the West and the foreign country respectively specialize in good A and in good M, shown as figure 3[14].

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[12] Brezis et al.(1993) analyzed the only case of surpassing that of the counterpart, which results in leapfrogging as a natural consequence. But this paper focuses on the more interesting case of immediate level of innovation: the case of not totally surpassing the counterpart's.

[13] The location-specific type innovation is presumed in this Ricardian Model such as the irrigated or reclaimed land and the improvement of water supply and the telecommunication system.

[14]The post-innovation production pattern (PIPP) conditions in Case 1 and Case 2 are in Appendix 2.

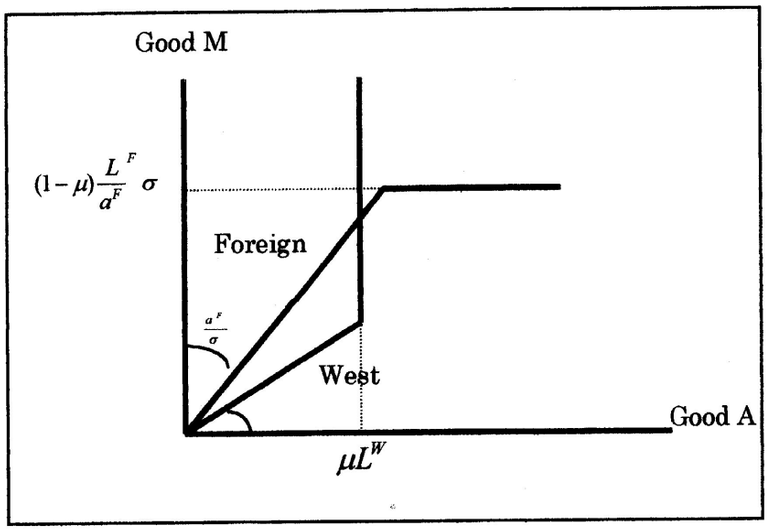

Figure 2 The offer curves in the West in Case 1

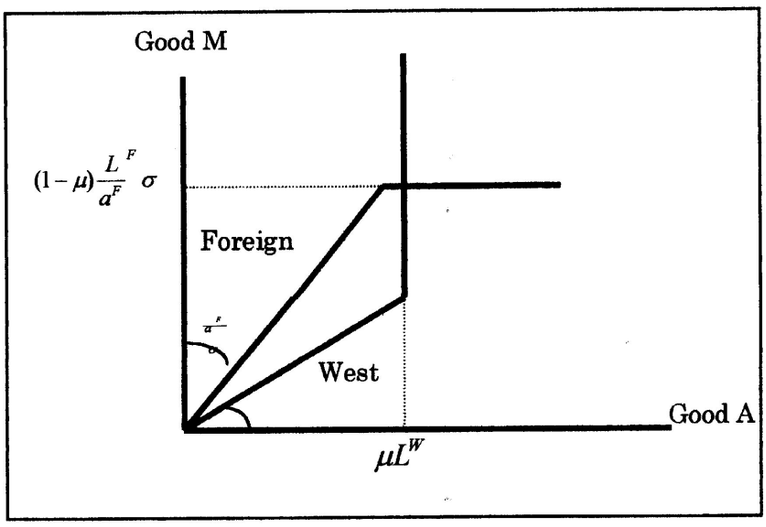

Figure 3 The offer curves in the West in Case 2

Migration and the change of production pattern once more

The change of the production pattern through innovation may cause people to have incentive to emigrate to the East in some cases[15].

Case 1: The West incompletely specializes in good M and good A

The relative prices in each region after innovation and before migration are

$$\left(\frac{p_M}{p_A}\right)^W = \frac{a^F w^F}{w^w \sigma} = a^W \quad \left(\frac{p_M}{p_A}\right)^F = \frac{a^F w^F \sigma}{w^W} = a^W \sigma^2 \ . \tag{9}$$

The wage rate ratio of the West and the foreign country is

$$\frac{w^F}{w^W} = \frac{a^W \sigma}{a^F}, \tag{10}$$

which is independent from the population ratio. Thus, the migration has no effect on the wage rate and terms of trade between the foreign country and the West.

Next, we check the stability, which examines whether some people in the West have some incentive to deviate to the East. If the people have it, the migration to the East will occur and the production pattern may change. The individual utilities in the West

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[15] Migration is assumed to occur simultaneously at some point on the basis of the utility function in each region. Matsuyama and Takahashi (1998) dealt with the migration process as a Poisson process in the dynamic path.

and in the potentially existing East are respectively

$$V^W = \frac{w^W}{e(P_1^W, P_2^W)} = \left(\frac{w^W}{w^E}\right)^{1-\mu} \frac{1}{\left[\left(\frac{\mu}{1-\mu}\right)^{1-\mu} + \left(\frac{1-\mu}{\mu}\right)^{\mu}\right](a^W)^{\mu}} \qquad (11)$$

$$V^E = \frac{w^E}{e(P_1^E, P_2^E)} = \left(\frac{w^E}{w^W}\right)^{1-\mu} \frac{1}{\left[\left(\frac{\mu}{1-\mu}\right)^{1-\mu} + \left(\frac{1-\mu}{\mu}\right)^{\mu}\right](a^E)^{\mu}\left(\frac{1}{\tau}\right)^{1-\mu}} \qquad . (12)$$

This is because some deviating people would produce good M in the East, using the higher technology in the East than in the West. Then we can get the stability in the necessary condition where people concentrate on the West, induced from the relative utility ratio:

$$\frac{V^E}{V^W} = \left(\frac{a^W}{a^E}\tau^2\right)^{1-\mu}\left(\frac{a^W}{a^E}\right)^{\mu} = \frac{a^W}{a^E}\tau^{2(1-\mu)} < 1. \qquad (13)$$

This condition is always satisfied in this case, because of the IC condition (8). Since the IC condition is equal to the stability condition, the binding condition is the only PIPP condition.

As the people devastate the East and concentrate on the West, the home country and the foreign country turn around the production pattern[16]. The necessary conditions for this case are the higher international trade costs and the small scale of innovation,

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[16] This turn-round is similar to leapfrogging in Brezis(1993).

induced from the PIPP conditions. The reason for the concentration comes from the superiority of the lower price of good A in the West to the production of only good M by the higher technology in good M in the East, because of the higher transportation costs imposed on the import of good A in the case of the concentration on the East.

Proposition 1 *The turn-around production pattern and the concentration on the West*

'The turn-around of production pattern' may occur in the case of the higher international trade costs and in that of the small scale of innovation.

Case 2: The West completely specializes in good A

This case is the specialization in good M in the foreign country (Case2-1) at first, but additionally while the migration to the East increases, the foreign country at times shifts from the complete specialization to the incomplete specialization (Case2-2).

Case2-1: The foreign country specializes in good M

The terms of trades in the foreign country and in the West are shown as

$$\left(\frac{p_M}{p_A}\right)^W = \frac{a^F w^F}{w^w \sigma} \qquad \left(\frac{p_M}{p_A}\right)^F = \frac{a^F w^F \sigma}{w^W} \quad . \qquad (14)$$

The relative wage ratio is induced as

$$\frac{w^F}{w^W} = \frac{\mu}{1-\mu}\frac{L^W}{L^F} . \qquad (15)$$

Then the stability is examined. If some people deviate to the East, the East specializes in good M, and the wage rate ratios and the terms of trade are shown as

$$\left(\frac{p_M}{p_A}\right)^E = \frac{a^E w^E \tau}{w^W} \tag{16}$$

$$\frac{w^E}{w^W} = \frac{\mu}{1-\mu}\frac{a^F \tau L^W}{a^F \tau L^E + a^E \sigma L^F}. \tag{17}$$

The individual utilities in the two regions are respectively

$$V^W = \frac{w^W}{e(P_1^W, P_2^W)} = \left(\frac{w^W}{w^E}\right)^{1-\mu} \frac{1}{\left[\left(\frac{\mu}{1-\mu}\right)^{1-\mu} + \left(\frac{1-\mu}{\mu}\right)^{\mu}\right]\left(\frac{a^E}{\tau}\right)^{1-\mu}} \tag{18}$$

$$V^E = \frac{w^E}{e(P_1^E, P_2^E)} = \left(\frac{w^E}{w^W}\right)^{1-\mu} \frac{1}{\left[\left(\frac{\mu}{1-\mu}\right)^{1-\mu} + \left(\frac{1-\mu}{\mu}\right)^{\mu}\right]\left(a^E\right)^{\mu}\left(\frac{1}{\tau}\right)^{1-\mu}}. \tag{19}$$

Then each wage rate ratio is inserted into each utility equation (18) and(19),

$$V^E(L^E) = \left(\frac{\mu}{1-\mu}\right)^{1-\mu}\left(\frac{a^F \tau(L-L^E)}{a^F \tau L^E + a^E \sigma L^F}\right)^{1-\mu} \frac{1}{\left[\left(\frac{\mu}{1-\mu}\right)^{1-\mu} + \left(\frac{1-\mu}{\mu}\right)^{\mu}\right]\left(a^E\right)^{\mu}\left(\frac{1}{\tau}\right)^{1-\mu}} \tag{20}$$

$$V^W(L^E) = \left(\frac{1-\mu}{\mu}\right)^{1-\mu}\left(\frac{a^F \tau L^E + a^E \sigma L^F}{a^F \tau(L-L^E)}\right)^{1-\mu} \frac{1}{\left[\left(\frac{\mu}{1-\mu}\right)^{1-\mu} + \left(\frac{1-\mu}{\mu}\right)^{\mu}\right]\left(\frac{a^E}{\tau}\right)^{1-\mu}} \tag{21}$$

By differentiating (20) and (21) in terms of L^E, we get:

$$\frac{\partial V^E(L^E)}{\partial L^E} < 0, \quad \frac{\partial V^W(L^E)}{\partial L^E} > 0. \quad (22)$$

These imply that the utility in the East decreases to the population in the East whereas that of the West increases to it as in Figure 4. Thus, people migrate until the gap of utilities are offset, and reach the stable equilibrium[17]. In the equilibrium, the population in the East is

$$L^{E*} = \frac{\left(a^E\right)^{\frac{2\mu-1}{2(\mu-1)}}\left(\frac{\mu}{1-\mu}\right)a^F\tau L - a^E\sigma L^F}{a^F\tau\left(1+\left(a^E\right)^{\frac{2\mu-1}{2(\mu-1)}}\left(\frac{\mu}{1-\mu}\right)\right)}. \quad (23)$$

This population distribution implies that the lower the level of technology in the foreign country, the larger the population is in the East in the equilibrium. On the other hand, the lower the transportation cost in international trade (the higher σ is), the smaller the population in the East.

This case indicates the trade-off between the specialization in good A in the West and in good M in the East. This specialization in the West results from the larger innovation in the foreign country and higher international transportation costs.

Proposition 2 *In the case of large σ (the low international transportation cost) and*

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[17] In some cases, in the process of offsetting this gap, the production propattern may convert into case 2-2.

large scale of innovation, the diversification tends to occur in the home country, in which the lower international trade cost leads the smaller population in the East, and the larger population in the West. Furthermore, 'industrialization' is made in the foreign country, which completely continues producing and specializing in good M.

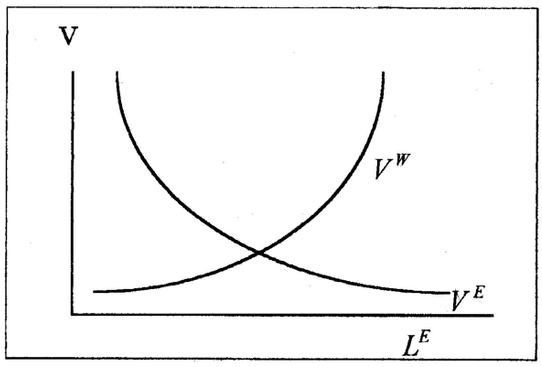

Figure 4 The utility function in each region

Case 2-2: The foreign country shifts to the incomplete specialization by means of migration.

At first the foreign country completely specializes in good M just after the innovation, even if there is some degree of migration to the East, but when the population in the East (23) is large, the foreign country turns to the incomplete specialization. We can also see this change from the offer curves in figure 5. The immigration to the East expands the offer curve of the East upward, while the offer of the West curve shrinks. This may cause the offer curve in the West to cut the slope in the foreign country's curve, which indicates the foreign country turns from the specialization to the incomplete specialization. In the other case, the foreign country

incompletely specializes in both goods immediately after innovation.

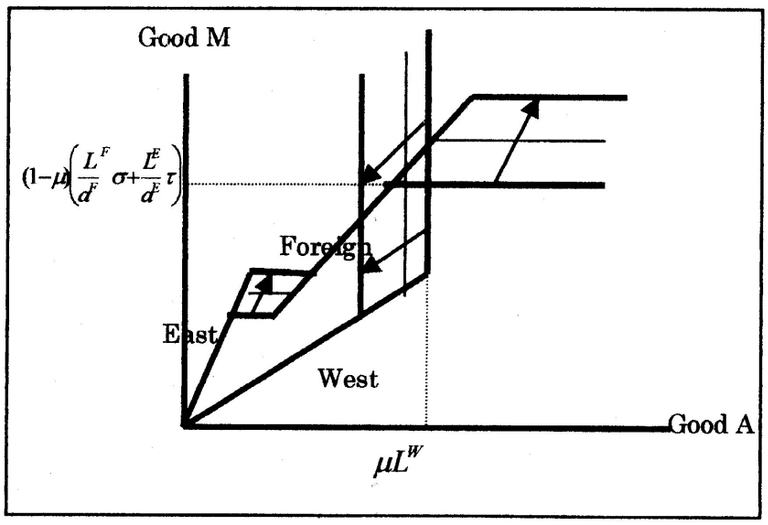

Figure 5 From Case2-1 to Case2-2

The relative prices in the East and in the West and in the foreign country are

$$\left(\frac{p_2}{p_1}\right)^E = \frac{a^E w^E \tau}{w^W} \qquad \left(\frac{p_2}{p_1}\right)^W = \frac{a^F w^F}{w^W} \qquad (24)$$

The wage rate ratio is shown as

$$\frac{w^E}{w^F} = \frac{\tau a^F}{\sigma a^E} \quad \frac{w^F}{w^W} = \frac{1}{\sigma} \quad \frac{w^E}{w^W} = \frac{\tau a^F}{\sigma^2 a^E}, \qquad (25)$$

all of which are unrelated to the population. The wage rate ratios depend on the input coefficients and transportation costs.

The utilities in the two regions, substituting (24), are

$$V^E = \left(\frac{a^F \tau}{a^E \sigma^2}\right)^{1-\mu} \frac{1}{\left[\left(\frac{\mu}{1-\mu}\right)^{1-\mu} + \left(\frac{1-\mu}{\mu}\right)^{\mu}\right]\left(a^E\right)^{\mu}\left(\frac{1}{\tau}\right)^{1-\mu}} \qquad (26)$$

$$V^W = \left(\frac{a^E \sigma^2}{a^F \tau}\right)^{\mu} \frac{1}{\left[\left(\frac{\mu}{1-\mu}\right)^{1-\mu} + \left(\frac{1-\mu}{\mu}\right)^{\mu}\right]\left(\frac{a^E}{\tau}\right)^{\mu}}, \qquad (27)$$

which are independent of the distribution of the population. Thus the relative utility is

$$\frac{V^E}{V^W} = \frac{a^F}{a^E}\frac{1}{\sigma^2}\tau^{2(1-\mu)}, \qquad (28)$$

where this condition is similar to the IC condition(8). But, since the production pattern changes, the condition becomes a function not only of the transportation cost in the internal economy and of the input coefficient in the East, but also of the transportation cost in the international trade and of the input coefficient in the foreign country. If the relative utility ratio (28) becomes more than unity, the people migrate to the East, and concentrate there, because the relative utility is independent from the population ratio. Once the migration occurs, the movement cannot always stop and can lead concentration. This case cannot occur the change of production pattern. If the concentration on the East is stable, this is 'the failure of innovation' (Case2-2a). If the concentration on the East is unstable, then the people migrate back to the West again, which is the case of industrialization (Case2-2b).

Case2-2a is an interesting situation where the foreign country and the East

respectively specialize in good A and good M after the concentration on the East [18]. This case tends to occur in the middle level of international transportation costs and innovation, induced from all of the conditions. This blunder boils down to the specialization in good M in the East and in good A in the foreign country. This concentration comes from the superiority of the highest technology in the East to the transportation costs imposed on the importing good A from the foreign country.

In Case2-2b, after the concentration, once the incomplete specialization in the foreign country and the specialization in good M in the East, some people migrate to the West, and dispersion appears, because of the instability in the concentration on the East[20]. This demonstrates a case of 'Industrialization' and the foreign country begins to produce good M, while the East specializes in good M and the West specializes in good A.

Proposition 3 *The failure of innovation*

The middle of international transportation costs and innovation results in the failure of innovation.

4. The start from the concentration on the East

In this section, in the initial equilibrium it is assumed to be the concentration on the East, contrast to the former section[17]. This case implies the larger technological gap

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[18] See Appendix 3 on the analysis on the stability.

[20] See Appendix 3 on the stability condition.

[17] The IC condition is reversal to (8), which is more than unity.

between regions and the lower interregional trade costs. The foreign country and the East respectively specialize in good A and good M, parallel to the discussion in the last section. After innovation in the foreign country, the production pattern changes in two ways[19]. One is that the foreign incompletely specializes in both goods (Case 3)[18]. The other is that the foreign country still completely specializes in good A, but this case has no change through the foreign innovations. Hence we can focus on only Case 3.

Case 3 Incomplete specialization in the foreign country after the innovation

The terms of trade are shown as

$$\left(\frac{p_M}{p_A}\right)^E = \frac{a^E w^E \sigma\tau}{w^F} \qquad \left(\frac{p_M}{p_A}\right)^F = \frac{a^F w^F}{w^F} = a^F . \quad (29)$$

The wage rate ratio is shown as

$$\frac{w^F}{w^E} = \frac{a^E}{a^F \sigma\tau} \quad (30)$$

Next, we induce the stability condition, and consider the deviation from the East. The deviation leads the terms of trade in the West:

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[19] The same assumption is set so that the foreign country can overcome that of the West, and not do that of the East, as in the previous section.

[18] See Appendix 2 about the PIPP conditions.

$$\left(\frac{p_M}{p_A}\right)^W = \frac{a^E w^E}{\tau w^W} \qquad (31)$$

The utilities in the East and in the West are

$$V^E = \left(\frac{w^E}{w^W}\right)^{1-\mu} \frac{1}{\left[\left(\frac{\mu}{1-\mu}\right)^{1-\mu} + \left(\frac{1-\mu}{\mu}\right)^{\mu}\right]\left(a^E\right)^{\mu}\left(\frac{1}{\tau}\right)^{1-\mu}} \qquad (32)$$

$$V^W = \left(\frac{w^W}{w^E}\right)^{\mu} \frac{1}{\left[\left(\frac{\mu}{1-\mu}\right)^{1-\mu} + \left(\frac{1-\mu}{\mu}\right)^{\mu}\right]\left(\frac{a^E}{\tau}\right)^{\mu}} . \qquad (33)$$

The relative utility ratio is

$$\frac{V^E}{V^W} = \frac{a^F}{a^E}\frac{1}{\sigma^2}\tau^{2(1-\mu)}. \quad (34)$$

If this ratio is more than unity, people concentrate on the East (Case 3-1). On the other hand, if it is less than unity, people move to the West (Case3-2).

Case3-1 The concentration on the East

This case indicates to keep the production pattern after the innovation, which is the incomplete specialization in the foreign country and the specialization in the East. This case is always stable. As a conclusion, the foreign country succeeds in 'the

industrialization', and incompletely specializes in both goods, while the East specializes in good M.

Case3-2 The concentration on the West

If the people return to the West, there are two production patterns in the West and the foreign country: Case 3-2a is the specialization in good A in the West, and the complete specialization in good M. Case3-2b is the incomplete specialization in the West, and the specialization in good M in the foreign country[19]. Some of these patterns are the same as the previous cases: Case3-2a is correspondent to Case 2-1. Case3-2a results in dispersion, and the foreign country realizes industrialization. Although Case 3-2b is similar to Case 1, the IC conditions are converse to each other, that is $\frac{V^E}{V^W}=\frac{a^W}{a^E}\tau^{2(1-\mu)}<1$ in Case 1 and $\frac{V^E}{V^W}=\frac{a^W}{a^E}\tau^{2(1-\mu)}>1$ in Case3-2b. Therefore, after the migration the concentration on the West is always unstable, contrast to the consequence in Case 1. Again the people emigrate to the East without regard to the population ratio, but the concentration on the East is also unstable because (33) is less than unity, and the migration to the West occurs again and again. This coming and going by the migrations continues to cycle permanently from the forever instability in the immigrant regions.

Proposition 4

In the case of starting from the concentration on the East, the innovation causes only the industrialization, not causes the failure of innovation and the turn-around of

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[19] See Appendix 3 on the conditions for Case 3-2a and Case 3-2b and see Appendix 4 on the reason for the removal of the case where the West incompletely specializes and the foreign country specializes in good A.

the production pattern. However, surprisingly the middle level of international trade costs may lead the teeter of the concentration like Case 3-2b, and cannot compose specific equilibrium.

5. Some implications

From this analysis, the recent reduction of tariff rates and transportation costs leads to fall down the international cost ($1/\sigma$), which shrinks the range of the turn-around of production pattern. This tends to industrialize the foreign country, and disperse to the two regions in the home country. The conclusion of happening industrialization easily rather than the turn-around is contrast to Brezis (1993), which concluded that the leapfrogging always occurs easily so as to cycle. This paper suggests that in the case of lower international trade costs it is easy to industrialize the developing country through innovations, but it is not easy to overcome the counterpart and turn around the production pattern. Furthermore this tendency for industrialization derives from the dispersion in the home country. This conclusion is very similar to Krugman and Livas (1996), which concluded the reduction of international trade costs leads to disperse, although this paper excludes controversial simulation analyses and takes technological innovation into account.

In the recent lower international trade costs, the Asian growth and the transformation in the industrial structure and geographical location may have some linkages. From this analysis, if the innovation in the Asian countries is small in scale, the turn-around of the production pattern with the U.S. and the concentration on the West coast states may occur. Or even if the innovation is large, the industrialization

carried out in the Asian countries, and the dispersion in the U.S. will bring the West to prosper.

6. Conclusions

This paper examines the impacts of the foreign innovation to geographical changes in the home country. The innovation effects are beyond the national border, and decide the location pattern in the other country. This has the following four provisional consequences. First, even if the technology in the foreign country can overcome that of less advanced technological region and cannot leapfrog that of the advanced technological region, the turn-around of the production pattern can be achieved. Interestingly, even small scale of innovation can change the pattern. Second, however, there are possibilities of the failure of innovation through the migration and the concentration on the advanced region in the home country. This failure suggests that though the foreign country initiates the production of manufacturing goods, it returns to the specialization in agriculture through the migration in the home country. Third, in the case of the starting from the concentration on the East, the stable equilibrium cannot exist, and the teetering between regions in the country together with migrating forever. Finally, the international transportation costs have effects, accompanied with the foreign innovation.

To continue further this research, the policy analysis will be needed. For instance, the subsidy for innovation is imposed, or the regional scheme in the infrastructure and urban planning are carried out. This framework will examine these effects. Also the connection to the real world is important. The relationship between the Asian growth

and the geographical change in the U.S. should be anatomized by empirical studies in order to support and justify this paper.

Appendix 1 Initial condition for production pattern (ICPP)

The conditions for the initial production pattern are induced from offer curves. In all cases, the foreign country specializes in good A. Also in Case 1 and Case 2, the West specializes in good M, while in Case 3, the East specializes in good M.

The ICPP for Case 1 and Case 2

The conditions for the specialization in good M in the West and those for the specialization in good A in the foreign country are

$$\sigma(1-\mu)\frac{L^W}{a^W} > \mu\frac{L^F}{\overline{a}^F}, \quad \text{(A1-1)}$$

($\overline{a}^F$ is constant) and

$$(1-\mu)L^W < \sigma\mu L^F. \quad \text{(A1-2)}$$

The following relations are respectively induced from (A1-1) and (A1-2):

$$\sigma > \frac{\mu}{1-\mu}\frac{a^W}{\overline{a}^F} \quad \text{(A1-3)}$$

$$\sigma > \frac{1-\mu}{\mu}. \quad \text{(A1-4)}$$

For simplicity, we can assume the large gap of the input coefficients between the foreign country and the West without hitch and can induce the larger the right side of (A1-4) than the right side of (A1-3). This leads to only (A1-4) as the binding condition.

The ICPP for Case 3

These are the nearly identical to the previous equations (A1-3) and (A1-4):

$$\sigma > \frac{\mu}{1-\mu}\frac{a^E}{\overline{a}^F}\frac{1}{\tau} \quad \text{(A1-5)}$$

and

$$\sigma > \frac{1-\mu}{\mu}\frac{1}{\tau}. \qquad \text{(A1-6)}$$

Also we can narrow only (A1-6) for simplicity because of the same assumption of the large gap of the input coefficients.

Appendix 2 Post-innovation production pattern (PIPP) condition

Case 1

This condition for the production pattern derives from Figure 1:

$$\sigma(1-\mu)\frac{L^F}{a^F} < \mu\frac{L^W}{a^W}, \quad \text{(A2-1)}$$

and

$$(1-\mu)L^F < \sigma\mu L^W. \qquad \text{(A2-2)}$$

We obtain the following relation from (A2-1) and (A2-2):

$$\frac{1-\mu}{\mu} < \sigma < \frac{a^F}{a^W}\frac{\mu}{1-\mu}. \quad \text{(A2-3)}$$

Case 2

This condition for the production pattern derives from Figure 2:

$$\sigma a^W \frac{(1-\mu)}{\mu} > a^F, \quad \text{(A2-4)}$$

and

$$\frac{(1-\mu)}{\mu} < \sigma. \qquad \text{(A2-5)}$$

Case 3

We can get the following relations:

$$\sigma > \frac{1-\mu}{\mu}\frac{a^F}{a^E}\frac{1}{\tau} \quad \text{(A2-6)}$$

Appendix 3 Some conditions

Production condition in the final equilibrium in Case 2-1

$$\frac{L^F}{\frac{\mu}{1-\mu}\frac{L^W}{a^W}-\tau\frac{L^E}{a^E}}\sigma > a^F \quad \text{(A3-1)}$$

This condition is not binding, because the PIPP condition (A2-5) is always more tight than (A3-1). Therefore this condition is always satisfied as long as (A2-5) is satisfied.

Production pattern condition for Case 2-2a and Case2-2b

The fork between Case 2-2a and Case 2-2b lies in the difference of production pattern after the concentration on the East. Case 2-2a is the specialization in good A in the foreign country, while Case 2-2b is the incomplete specialization. The conditions for Case 2-2a and Case 2-2b are shown as

$$a^F > \frac{\mu}{1-\mu}a^E\frac{1}{\tau\sigma}$$

and

$$a^F < \frac{\mu}{1-\mu}a^E\frac{1}{\tau\sigma}.$$

The stability condition in Case 2-2a

The stability condition for the concentration on the East is necessary to be more than unity in the relative utility function.

$$\frac{V^E}{V^W}=\frac{w^E}{w^W}\frac{1}{\tau}=\frac{\mu}{1-\mu}\frac{\sigma L^F+L^W}{L^E}\frac{1}{\tau}>1 \quad \text{(A3-2)}$$

Only a few people are assumed to deviate to the West. Hence, the population in the West is very close to zero, which is shown as:

$$\frac{1-\mu}{\mu}\tau<\sigma \quad \text{(A3-3)}$$

This is always satisfied from the initial condition (A1-4). Therefore the concentration on the East is always stable.

The stability condition in Case 2-2b

The condition for the stability in the East is

$$\left(\frac{\mu}{1-\mu}\frac{L^W+\sigma L^F}{L^E}\right)^{2(1-\mu)}>\frac{1}{\tau}, \qquad \text{(A3-4)}$$

Only a few people are assumed to deviate to the West. Hence, the population in the West is very close to zero, which is shown as:

$$\left(\frac{1}{\tau}\right)^{\frac{1}{2(1-\mu)}}\frac{1-\mu}{\mu}<\sigma \qquad \text{(A3-5)}$$

which is induced from the necessity of $\frac{V^E}{V^W}>1$. Thus, if the condition is satisfied, the concentration on the East is sustainable, and the East specializes in good M while the foreign country incompletely specializes. On the other hand, if this stability condition is not satisfied, the deviation to the West occurs. Until (A3-4) is equal to unity, the migration will continue so as to offset the gap of utility. This unstable case is the specialization in good A in the West, and the specialization in good M in the East, and the incomplete specialization in the foreign country.

The production pattern for Case 3-2a and Case 3-2b

The fork between Case 3-2a and Case 3-2b lies in the difference of production pattern after the concentration on the West. Case 3-2a is the specialization in good M in the foreign country, while Case 3-2b is the incomplete specialization. The conditions for Case 3-2a and Case 3-2b are shown as

$$a^F < \frac{1-\mu}{\mu} a^W \sigma$$

and

$$a^F > \frac{1-\mu}{\mu} a^W \sigma .$$

Appendix 4

We can exclude some cases from the initial assumptions such as $0<\sigma, \tau<1$, $\mu>0.5$ and LH=LF.

Case 1 and Case 2

We can eliminate the case of the incomplete specialization in the foreign country and the specialization in good A in the West. The production condition is shown as:

$$\frac{(1-\mu)}{\mu} > \sigma .$$

However this condition cannot be held from the ICPP condition (A1-4), and this pattern cannot exist and can be excluded.

Case3-2

While the people concentrate on the West after the innovation, we can exclude the case where the foreign country incompletely specializes and the West specializes in good A. This is because $\sigma\tau > \frac{1-\mu}{\mu}$ cannot hold under $0<\sigma\ \tau<1$ and $\mu>0.5$.

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